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Risk of Reulceration and Reamputation after Minor Lower Extremity Amputation in Type 2 Diabetes: Systematic Review/Meta Analysis

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Abstract

Background: Diabetes is one of the most common chronic diseases in the world. The incidence of diabetes has increased steadily in recent years. Type 2 diabetes mellitus has reached epidemic proportions, affecting 56 million people in Europe (i.e., 8.5% of the adult population).

Aim of Study: To establish, through the available literature the risk of re-ulceration, re-amputation in diabetic patients following minor lower limb extremity amputation.

Patients and Methods: The following electronic databases were searched up to 2019: PubMed, Google Scholar search engine, Cochrane database of systematic reviews, EMBASE and Science Direct, Wiley Online Library, The Journal of Ankle and Foot Surgery and Clinical Key database searching keywords and terms listed below: "Diabetic foot; Mortality; Toe amputation, Ulcers diabetic foot, Mid-foot amputation, Minor amputation, Peripheral vascular disease".

Results: In our meta-analysis, risk factors for the recurrence of DFUs included male gender, smoking, long duration of diabetes, long duration of past DFUs, plantar ulcers, PAD, and DPN. Also significant differences were found in age. On the other hand there was no relation between BMI and recurrence of DFUs.

Conclusion: The results of this meta-analysis showed that gender, smoking, duration of diabetes, BMI and hypertension were risk factors for DFU recurrence. By identifying these factors, health care staff could focus on the identified risk factors for the recurrence; hence, patients with a relatively higher risk of DFU recurrence could be treated in a more timely manner.

Key Words: *Reulceration – Reamputation – Type 2 diabetes.*

Introduction

THE natural history of diabetic neuropathy remains unclear, the late squeals of the disease include foot ulceration and, in the worst scenario, amputation **[1]**. According to community-based studies from North America and European countries, the annual incidence of diabetic foot ulcers ranges from 0.6% to 2.2% **[2]**. It has been estimated that diabetes and its comorbidities account for 50% of the lower extremity amputations performed worldwide **[3]**, and an estimated 85% of all diabetes-related amputations are preceded by a foot ulcer **[4]**.

A Diabetic Foot Ulcer (DFU) is the most common cause of non-traumatic Lower-Extremity Amputations (LEAs) associated with diabetes. It not only causes great physical and mental pain in the patients, but is also a considerable financial burden on the patients' families and society as a whole. Toe amputation has the highest incidence among diabetic LEAs. Many epidemiological reports have published data regarding the incidences of amputation and mortality after LEAs **[5]**.

Neuropathy, foot ulceration and, in the worst cases, amputation, lead to limited joint mobility in 30% to 40% of diabetic patients, especially in the ankle joint and first metatarsophalangeal joint [6]. Joint impairment can lead to functional gait variations, and their severitydepends on the extent of the neuropathy, ulcers, and level of amputation [7]. Peripheral neuropathy, high-pressure areas on the sole of the foot, prolonged activity limited joint mobility, and foot deformity have been linked to the development of foot ulcerations **[8]**, the most common component in the causal pathway to limb amputation in people with diabetes **[9]**. In the case of partial foot amputations, disruption of normal foot biomechanics probably increases existing areas of high pressure and the risk of ulceration **[10]**.

The big toe plays an important role in foot biomechanics. During walking, it poses twice the total pressure of the other four toes **[11]**. Since the great toe is passively dorsi-flexed, the longitudinal

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arch of the foot is raised, the rearfoot supinated, the leg externally rotated, and the plantar aponeurosis tensed **[12]**. This is called windlass mechanism and is of great importance since it tenses the plantar fascia thus forming a rigid lever of the foot for push-off **[9]**. If the mechanism is altered, the timing and effectiveness of push-off would be affected. Therefore, great toe amputation will change intensely in foot biomechanics.

Definition and classification of amputations:

LEA was defined as the partial or total resection of the lower limb, through one or more bone structures and perpendicular to the longitudinal axis of the limb **[13]**.

There were two types of amputation:

1- Major amputation was defined as being above the ankle (below-knee and above-knee).

2- Minor amputation as being limited to the foot (from digital to Syme) **[14]**.

Re-amputation:

Re-amputation was defined as the second LEA performed on the same person. The re-amputations considered were those performed at the ipsilateral level and on the same or a superior anatomical plane, or at the contralateral level. Surgical revision of the stump was not considered as an amputation **[15]**.

Aim of the study:

This study seeks to establish, through the available literature the risk of re-ulceration, re-amputation in diabetic patients following minor lower limb extremity amputation.

Patients and Methods

Literature search strategy:

The following electronic databases were searched up to 2019: PubMed, Google Scholar search engine, Cochrane database of systematic reviews, EMBASE and Science Direct, Wiley Online Library, the Journal of Ankle and Foot Surgery and Clinical Key database searching keywords and terms listed below: “Diabetic foot; Mortality; Toe amputation, Ulcers diabetic foot, Mid-foot amputation, Minor amputation, Peripheral vascular disease”.

Also full copies of articles of available medical journals and other published studies identified by the search, considered to meet the inclusion criteria, based on their title, abstract and subject descriptors, were obtained for data synthesis.

Types of participants:

This review considered all studies that involved type 2 diabetic patients undergoing non-traumatic minor LEAs.

Types of interventions:

Interventions of interest included those related to clinical outcomes of minor LEAs in patients with type 2 diabetes.

Types of outcome measures:

The primary outcome was reviewing clinical outcomes of minor LEAs in patients with type 2 diabetes and secondary outcome to be included was to determine the predictors for re-ulceration, re-amputation and mortality.

Study inclusion and exclusion criteria:

Studies were included if the following criteria were met: (A) Diabetic patients with healed foot ulcerations, (B) Case-control study or cohort study, (C) Comparison groups of recurrence and non-recurrence, (D) Data on the risk factors for recurrence of DFUs reported as Odds Ratios (ORs) with 95% confidence intervals (95% CI), and (E) English or Chinese article. Editorials, reviews, letters, and comments were excluded from this analysis.

Data abstraction and quality appraisal:

A data extraction form was designed for the included studies. The following data were independently extracted by one researcher: First author, year of publication, location of study, type of study design, population size (recurrence/non-recurrence), sample ages, follow-up time, and risk factors. We also contacted the authors about unclear or missing information when necessary.

The methodological quality of included studies was independently assessed using the validated Newcastle-Ottawa Scale (NOS). The NOS is based on an accumulative score in each of three categories: Selection, comparability, and exposure or outcome. The NOS scores range between 0 and 9 stars. Studies with 6 to 9 stars were considered to be at low Risk of Bias (ROB), studies with 4 to 5 stars were considered to be at medium ROB, and studies with 1 to 3 stars were considered to be at high ROB. Two researchers independently performed the quality assessment for included studies, and disagreement was resolved by discussion.

Results

The seventeen studies included in the systematic review and meta-analysis was retrospective cohort studies published between 2006 and 2018. A total

of 3022 patients were involved and mean ranged from 51.73 to 72.6 years. Three studies failed to provide a mean age for participants, the characteristics of the included studies are listed in (Table 1).

Table (1): Characteristics of the included studies (N=17).

Papers	Number of patients	Male		Female		Mean of age	Average follow-up duration (month)
		No.	%	No.	%		
• Pollard et al., **[16]**	101	78	77.2	23	22.8	64.3	25.2
• Blume et al., **[17]**	91	59	64.8	32	35.2	62	12
• Krause et al., **[18]**	65	42	64.6	23	35.4	57.9	28.8
• Younger et al., **[19]**	68	55	80.9	13	19.1	NR	NR
• Landry et al., **[20]**	62	37	59.7	25	40.3	60.7	NR
• Terashi et al., **[21]**	11	8	72.7	3	27.3	71	20
• Brown et al., **[22]**	21	NR	NR	NR	NR	53.8	60
• McCallum et al., **[23]**	12	10	83.3	2	16.7	52	NR
• Dubsk´y et al., **[24]**	73	60	82.1	13	17.8	NR	36
• O'Brien et al., **[25]**	1205	804	66.7	401	33.3	65	1
• Qian et al., **[26]**	108	NR	NR	NR	NR	68	12
• Yue-Jie and Xi-Wen, **[5]**	245	145	59.2	100	40.8	NR	36
• Hu et al., **[27]**	231	101	43.7	130	56.3	58.3	36
• Chang et al., **[28]**	282	175	62.1	107	37.9	65	37.14
• Khalifa, **[29]**	93	44	47.3	49	52.7	51.73	24
• Mo et al., **[30]**	189	118	62.4	71	37.6	66.60	44.83
• Xie et al., **[31]**	165	87	52.7	78	47.3	72.6	24

NR: No Report.

Seven of the 17 studies reported specific data on reulceration. The reulceration rate ranged from 0% to 75.9%. A total of 533 any level reulceration (31.6%) were reported after 1686 TMAs, and seven of the 17 studies reported specific data on reamputation. The reamputation rate ranged from 0% to 30.7%. A total of 116 any level reamputations (6.9%) were reported after 1686 TMAs.

Table (2): Characteristics of the included studies (N=17).

Papers	Number of patients	Number of patient had risk factor		Reul-ceration		Reampu-tation	
		No.	%	No.	%	No.	%
• Pollard et al., **[16]**	101	31	30.7	0	0.0	31	30.7
• Blume et al., **[17]**	91	48	52.7	25	27.5	23	25.3
• Krause et al., **[18]**	65	0	0.0	NR	NR	NR	NR
• Younger et al., **[19]**	68	0	0.0	NR	NR	NR	NR
• Landry et al., **[20]**	62	0	0.0	NR	NR	NR	NR
• Terashi et al., **[21]**	11	1	9.1	1	9.1	0	0.0
• Brown et al., **[22]**	21	4	19.0	2	9.5	2	9.5
• McCallum et al., **[23]**	12	2	16.7	1	8.3	1	8.3
• Dubsky´ et al., **[24]**	73	NR	NR	NR	NR	NR	NR
• O'Brien et al., **[25]**	1205	318	26.4	318	26.4	0	0.0
• Qian et al., **[26]**	108	NR	NR	NR	NR	NR	NR
• Hu et al., **[27]**	231	NR	NR	NR	NR	NR	NR
• Yue-Jie and Xi-Wen, **[5]**	245	245	100.0	186	75.9	59	24.1
• Chang et al., **[28]**	282	NR	NR	NR	NR	NR	NR
• Khalifa, **[29]**	93	NR	NR	NR	NR	NR	NR
• Mo et al., **[30]**	189	NR	NR	NR	NR	NR	NR
• Xie et al., **[31]**	165	NR	NR	NR	NR	NR	NR
Total	3022	1039	34.38	533	31.6	116	6.9

The following table shows that age is mentioned as a risk factor in three of the eight Papers by 37.5%, as the sex factor was mentioned in six Papers by 75%, as the smoking factor was mentioned in five Papers by 62.5%, as the BMI factor was mentioned in three Papers by 37.5%, as the duration of DM factor was mentioned in three Papers by 37.5%, as the duration of past diabetic foot ulcer factor was mentioned in one Papers by 12.5% plantar ulcer is mentioned as a risk factor in three of the one Papers by 12.5%.

Table (3): Meta-analysis of demographic factors for the recurrence of DFUs.

Papers	Risk factors						
	Age	Sex	Smoking	BMI	Duration of DM	Duration of past diabetic foot ulcer	Plantar ulcer
• Dubsk´y et al., **[24]**	No	Yes	Yes	No	No	No	Yes
• Qian et al., **[26]**	No	No	No	No	No	No	No
• Hu et al., **[27]**	Yes	Yes	No	Yes	Yes	No	No
• Yue-Jie and Xi-Wen, **[5]**	Yes	No	No	No	No	No	No
• Chang et al., **[28]**	Yes	Yes	Yes	Yes	Yes	Yes	No
• Khalifa, **[29]**	No	Yes	Yes	Yes	Yes	No	No
• Mo et al., **[30]**	No	Yes	Yes	No	No	No	No
• Xie et al., **[31]**	No	Yes	Yes	No	No	No	No
• *Total:*							
No.	3	6	5	3	3	1	1
%	37.5	75.0	62.50	37.5	37.5	12.5	12.5

The following table shows that the peripheral artery disease factor was mentioned in five Papers by 62.5%, as the diabetic peripheral neuropathy factor was mentioned in two Papers by 25.0%, as the diabetic nephropathy factor was mentioned in four Papers by 50.0%, as the diabetic retinopathy factor was mentioned in four Papers by 50.0%, as the HTN factor was mentioned in four Papers by 50.0% and the total cholesterol factor was mentioned in two Papers by 25.0%.

Two studies reported the relationship between age and the risk of DFU recurrence. However, obvious heterogeneity was found among the included studies (t=6.283, p=0.000).

Sex studies that included a total of 1036 patients provided eligible data for demonstrating the relationship between gender and DFU recurrence. The pooled results showed that males had a higher risk of developing DFU recurrence than females (χ^2= 45.374, p=0.000).

Table (4): Meta-analysis of clinical factors for the recurrence of DFUs.

Papers	Risk factors					
	Peripheral artery disease	Diabetic Peripheral neuropathy	Diabetic pathy	Diabetic pathy	HTN	Total cholesterol
• Dubsk´y et al., **[24]**	Yes	No	Yes	No	No	No
• Qian et al., **[26]**	No	No	No	No	No	Yes
• Hu et al., **[27]**	No	No	No	Yes	No	No
• Yue-Jie and Xi-Wen, **[5]**	No	No	No	No	No	No
• Chang et al., **[28]**	Yes	No	Yes	Yes	Yes	No
• Khalifa, **[29]**	Yes	Yes	Yes	Yes	Yes	Yes
• Mo et al., **[30]**	Yes	Yes	Yes	Yes	Yes	No
• Xie et al., **[31]**	Yes	No	No	No	Yes	No
• *Total:*						
No.	5	2	4	4	4	2
%	62.5	25.0	50.0	50.0	50.0	25.0

Table (5): Comparison between 2 Paper regarding age.

Papers	Age		Test value	*p*-value	Sig.
	Mean	SD			
Hu et al., **[27]**	58.3	10.2	6.283	0.000	HS
Chang et al., **[28]**	65	0			

Table (6): Comparison between 6 Paper regarding sex.

Papers	Sex				Test value	*p*-value	Sig.
	Male		Female				
	No.	%	No.	%			
Dubsk´y et al., **[24]**	60	10.26	13	2.90	45.374	0.000	HS
Hu et al., **[27]**	101	17.26	130	29.02			
Chang et al., **[28]**	175	29.91	107	23.88			
Khalifa, **[29]**	44	7.52	49	10.94			
Mo et al., **[30]**	118	20.17	71	15.85			
Xie et al., **[31]**	87	14.87	78	17.41			
Total	585	100.0	448	100.0			

Table (7): Comparison between 5 Paper regarding smoking.

	Smoking				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Dubsk´y et al., **[24]**	4	3.1	4	3.1	12.984	0.011	S
Chang et al., **[28]**	41	31.5	54	41.9			
Khalifa, **[29]**	25	19.2	7	5.4			
Mo et al., **[30]**	38	29.2	35	27.1			
Xie et al., **[31]**	22	16.9	29	22.5			
Total	130	100	129	100.0			

Five studies that included a total of 802 patients provided available data on the association between smoking and DFU recurrence. The pooled results showed that smoking was associated with an increased incidence of DFU recurrence (χ^2=12.984, *p* =0.011).

Table (8): Comparison between 3 Paper regarding BMI.

	BMI		Test value	*p*-value	Sig.
	Recurrence Mean ±	Non recurrence Mean ± SD			
Hu et al., **[27]**	23.3±2.8	22.6±2.3	–2.249	0.025	S
Chang et al., **[28]**	23.73±3.26	23.81±3.01	0.171	0.864	NS
Khalifa, **[29]**	29.63±4.51	31.54±3.97	2.081	0.042	S
Total	76.66±10.57	77.95±9.28	1.552	0.121	NS

Three studies available data were provided on the relationship between BMI and DFU recurrence. However, moderate homogeneity was found among the included studies (*t*=1.552, *p*=0.121).

Table (9): Comparison between 3 Paper regarding duration of DM.

	Duration of DM		Test value	*p*-value	Sig.
	Recurrence Mean ±	Non recurrence Mean ± SD			
Hu et al., **[27]**	13.5±5.7	7.5±3.2	–9.928	0.000	HS
Chang et al., **[28]**	11.74±6.53	9.77±7.02	–2.292	0.022	S
Khalifa, **[29]**	13.76±5.42	8.46±3.21	–5.303	0.000	HS
Total	39±17.65	25.73±13.43	–10.353	0.000	HS

The pooled results for 3 studies showed that that duration of DM was associated with an increased incidence of DFU recurrence (*t*=10.353, *p* =0.000).

Table (10): Comparison between 5 paper regarding peripheral artery disease.

Papers	Peripheral artery disease				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Dubsk´y et al., **[24]**	9	4.5	7	2.6	22.766	0.000	HS
Chang et al., **[28]**	69	34.2	131	48.0			
Khalifa, **[29]**	18	8.9	7	2.6			
Mo et al., **[30]**	65	32.2	57	20.9			
Xie et al., **[31]**	41	20.3	71	26.0			
Total	202	100.0	273	100.0			

Five studies provided extractable data to analyse the association between the risk of DFU recurrence and PAD. The fixed effects model showed that patients with PAD were at a significant risk of DFU recurrence (χ^2=22.766, *p*=0.000).

Two studies that included a total of 255 patients provided available data on the association between DPN and DFU recurrence. However, no significant difference was found between the combined estimates.

Table (11): Comparison between two Paper regarding diabetic peripheral neuropathy.

Papers	Diabetic peripheral neuropathy				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Khalifa, **[29]**	50	41.0	32	31.1	2.227	0.135	NS
Mo et al., **[30]**	73	59.3	71	68.6			
Total	123	100.0	103	100.0			

Table (12): Comparison between 4 Paper regarding diabetic nephropathy.

Papers	Diabetic nephropathy				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Dubsk´y et al., **[24]**	5	5.2	3	2.7	4.529	0.209	NS
Chang et al., **[28]**	37	38.1	58	51.8			
Khalifa, **[29]**	12	12.4	9	8.0			
Mo et al., **[30]**	43	44.3	42	37.5			
Total	97	100.0	112	100.0			

Four studies that included a total of 637 patients provided available data on the association between DN and DFU recurrence. However, no significant difference was found between the combined estimates.

Table (13): Comparison between 3 Paper regarding diabetic retinopathy.

Papers	Diabetic retinopathy				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Chang et al., **[28]**	41	46.6	78	62.4	5.804	0.054	NS
Khalifa, **[29]**	12	13.6	9	7.2			
Mo et al., **[30]**	35	39.8	38	30.4			
Total	88	100.0	125	100.0			

Three studies that included a total of 564 patients provided available data on the association between DR and DFU recurrence. However, no significant difference was found between the combined estimates.

Table (14): Comparison between 4 Paper hypertension.

Papers	Hypertension				Test value	*p*-value	Sig.
	Recurrence		Non recurrence				
	No.	%	No.	%			
Chang et al., **[28]**	52	33.3	86	43.9	11.922	0.007	HS
Khalifa, **[29]**	41	26.3	26	13.3			
Mo et al., **[30]**	46	29.5	53	27.0			
Xie et al., **[31]**	17	10.9	31	15.8			
Total	156	100.0	196	100.0			

Fourstudies that included a total of 729 patients provided available data on the association between Hypertension and DFU recurrence. However, highly significant difference was found between the combined estimates.

Discussion

Diabetic Foot Ulcers (DFUs) are one of the most serious complications in diabetic patients as they are perhaps the most common cause of diabetes-related hospitalization and may lead to amputation **[32]**.

It is estimated that the annual risk of developing a DFU in diabetic patients ranges from 19% to 34%. Approximately 40% of patients with DFUs experience a recurrence within 1 year after the ulcer has healed, nearly 60% within 3 years, and 65% within 5 years **[32]**.

Recurrent foot ulcerations result from various factors that have adverse effects on patients' physiological condition, mental health, and social functioning. In addition, these recurrent ulcers increase the patient's medical burden because of long-term costs related to wound management. Hence, it is necessary to identify the risk factors of recurrent DFUs and provide evidence for their prevention **[33]**. So, the aim of this metanalysis was seeks to establish, through the available literature the risk of re-ulceration, re-amputation and mortality in diabetic patients following minor lower limb extremity amputation, and the impact of activities of daily living on clinical outcomes.

The seventeen studies included in the systematic review and Meta-analysis was retrospective cohort studies published between 2006 and 2018. A total of 3022 patients were involved and mean ranged from 51.73 to 72.6 years. Three studies failed to provide a mean age for participants.

Seven of the seventeen studies reported specific data on reulceration. The reulceration rate ranged from 0% to 75.9%. A total of 533 any level reulceration (31.6%) were reported after 1686 TMAs, and seven of the 17 studies reported specific data on reamputation. The reamputation rate ranged from 0% to 30.7%. A total of 116 any level reamputations (6.9%) were reported after 1686 TMAs.

In our metanalysis, age is mentioned as a risk factor in three of the eight Papers by 37.5%, as the sex factor was mentioned in six Papers by 75%, as the smoking factor was mentioned in five Papers by 62.5%, as the BMI factor was mentioned in three Papers by 37.5%, as the duration of DM

factor was mentioned in three Papers by 37.5%, as the duration of past diabetic foot ulcer factor was mentioned in one Papers by 12.5% plantar ulcer is mentioned as a risk factor in three of the one Papers by 12.5%.

In our meta-analysis, risk factors for the recurrence of DFUs included male gender, smoking, long duration of diabetes, long duration of past DFUs, plantar ulcers, PAD, and DPN. Also significant differences were found in age. On the other hand there was no relation between BMI and recurrence of DFUs.

In our study, sex studies that included a total of 1036 patients Dubsk´y et al., **[24]**, Hu et al., **[27]**, Chang et al., **[28]**, Khalifa **[29]**, Mo et al., **[30]** and Xie et al., **[31]** provided eligible data for demonstrating the relationship between gender and DFU recurrence. The pooled results showed that males had a higher risk of developing DFU recurrence than females (X^2=45.374, p=0.000).

Meta-analysis results by Huang et al., **[32]** supports our results in showing that the risk of DFU recurrence in male patients was 1.38 times higher than that in female patients, which was consistent with the results of a previous study **[34]**.

Our results showed that five studies Dubsk´y et al., **[24]**, Chang et al., **[28]**, Khalifa **[29]**, Mo et al., **[30]** and Xie et al., **[31]** included a total of 802 patients provided available data on the association between smoking and DFU recurrence. The pooled results showed that smoking was associated with an increased incidence of DFU recurrence ($\chi 2$= 12.984, p=0.011).

Our result is consistent with these studies. Although several studies Dubsk´y et al., **[24]**, Chang et al., **[28]**, Mo et al., **[30]** and Waaijman et al., **[35]** reported that smoking was not a risk factor of DFU recurrence, these studies were limited in their small sample size, while our result was based on five studies according to previous studies, smoking affects the control of blood glucose in diabetic patients, which is closely related to the occurrence of DFUs. In addition, smoking can cause vasoconstriction and blood flow obstruction, leading to ischemia and affecting the repair of ulcers **[36]**.

As shown in our study, three studies Hu et al., **[27]**, Chang et al., **[28]** and Khalifa **[29]** were provided on the relationship between BMI and DFU recurrence. However, moderate homogeneity was found among the included studies (t=1.552, p= 0. 121).

The pooled results for 3 studies Hu et al., **[27]**, Chang et al., **[28]** and Khalifa **[29]** showed that that duration of DM was associated with an increased incidence of DFU recurrence (t=–10.353, p=0.000).

Our study also found that, with the progression of diabetes, the risk of DFU recurrence increases with high statistical significance which is consistent with the studies of Qian et al., **[26]** and Hu et al., **[27]** but studies conducted by Chang et al., **[28]** and Khalifa **[29]** found that the duration of diabetes was not an independent risk factor for DFU recurrence; however, the authors did not give any explanation for this negative result.

As commonly acknowledged, PAD can cause abnormalities in the microcirculation of the foot, resulting in poor blood supply; hence, the recurrence rate of DFUs in patients with PAD is high **[35]**.

Our study showed no significant differences between DFU and DPN. On the other hand, Huang et al., **[32]** metanalysis showed that DFU patients with DPN were at a higher risk of DFU recurrence unlike our results but was consistent with the results of a previous study by Connor and Mahdi **[37]**. DFU patients with DPN may experience feelings of abnormal temperature or pain sensations in their feet, and their perception of external stimuli will be weakened and easily damaged. Furthermore, sweat glands will be demineralized in case of autonomic neuropathy, which will make the skin on the foot dry, chapped, and prone to ulcers. In motor neuropathy, foot muscle atrophy leads to foot malformations, and foot compression imbalance is also prone to damage **[38]**.

Our study lacked for the duration of past DFUs as a risk factor of DFU recurrence but Hung et al., **[39]** metanalysis showed that duration of past DFUs was a risk factor of DFU recurrence. This might be explained by Mai et al., **[40]** study which showed that the risk of recurrent ulcerations in patients with a DFU >_2 months at the first visit was 1.93 times higher than that in patients with a DFU <2 months, which was related to the delayed visit and the improper treatment of wounds in patients with DFUs, suggesting that early and proper treatment should be carried out in the care of DFU patients for preventing recurrent ulcerations.

Conclusion:

The results of this meta-analysis showed that gender, smoking, duration of diabetes, BMI and hypertension were risk factors for DFU recurrence. By identifying these factors, health care staff

focus on the identified risk factors for the recurrence; hence, patients with a relatively higher risk of DFU recurrence could be treated in a more timely manner.

References

1- BOULTON A.J.: Lowering the risk of neuropathy, foot ulcers and amputations. Diabet. Med., 15 (4): S57-S59, 1998.

2- MOREY-VARGAS O.L. and SMITH S.A.: Be Smart: Strategies for foot care and prevention of foot complications in patients with diabetes. Prosthet. Orthot. Int., 39: 48-60, 2015.

3- MARKS R.M., LONG J.T. and EXTEN E.: Gait abnormality following amputation in diabetic patients. Foot Ankle Clin., 15: 501-7, 2010.

4- RASPOVIC A.: Gait characteristics of people with diabetes-related peripheral neuropathy, with and without a history of ulceration. Gait. Posture, 38: 723-8, 2013.

5- YUE-JIE C. and XI-WEN L.: Clinical outcomes of toe amputation in patients with type 2 diabetes in Tianjin, China; International Wound Journal ISSN 1742-4801: 2014.

6- FORMOSA C., GATT A. and CHOCKALINGAM N.: The importance of clinical biomechanical assessment of foot deformity and joint mobility in people living with type-2 diabetes within a primary care setting. Prim. Care Diabetes, 7: 45-50, 2013.

7- IRENE A. and MARCO G.: Does First Ray Amputation in Diabetic Patients Influence Gait and Quality of Life?; The Journal of Foot & Ankle Surgery, 57: 44-51, 2018.

8- QUEBEDEAUX T.L., LAVERY L.A. and LAVERY D.C.: The development of foot deformities and ulcers after great toe amputation in diabetes. Diabetes Care, 19 (2): 165- 7, 1996.

9- CHOU S.W., CHENG H.Y., CHEN J.H., et al.: The role of the great toe in balance performance. Journal of Orthopaedic Research, 27: 549-54, 2009.

10- MOTAWEA M.: International Journal of Advancement Research: Impact of big toe amputation in biomechanics, 3 (12): 1224-8, 2015.

11- TANAKA T., HASHIMOTO N., NAKATA M., et al.: Analysis of toe pressures under the foot while dynamic standing on one foot in healthy subjects. J. Orthop. Sports Phys. Ther., 23: 188-93, 1996.

12- HICKS J.H.: The mechanism of the foot. II. The plantar aponeurosis and the arch. J. Anat., 88: 25-30, 1954.

13- KENNON B., LEESE G.P., COCHRANE L., et al.: Reduced incidence of lower-extremity amputations in people with diabetes in Scotland: A nationwide study, Diabetes Care, 35 (12): 2588-90, 2012.

14- ALMARAZ M.C., GONZÁLEZ-ROMERO S., BRAVO M., et al.: Incidence of lower limb amputations in individuals with and without diabetes mellitus in Andalusia (Spain) from 1998 to 2006, Diabetes Res. Clin. Pract., 95 (3): 399-405, 2012.

15- KANADE R., VAN DEURSEN R., BURTON J., et al.: Re-amputation occurrence in the diabetic population in South Wales, UK. International wound journal, 4 (4): 344-52, 2007.

16- POLLARD J., HAMILTON G.A., RUSH S.M., et al.: Mortality and morbidity after transmetatarsal amputation: Retrospective review of 101 cases. J. Foot Ankle Surg., 45: 91-7, 2006.

17- BLUME P., SALONGA C., GARBALOSA J., et al.: Predictors for the healing of transmetatarsal amputations: Retrospective study of 91 amputations. Vascular, 15: 126-33, 2007.

18- KRAUSE F.G., DeVRIES G., MEAKIN C., et al.: Outcome of transmetatarsal amputations in diabetics using antibiotic beads. Foot Ankle Int., 30: 486-93, 2009.

19- YOUNGER A.S., AWWAD M.A., KALLA T.P., et al.: Risk factors for failure of transmetatarsal amputation in diabetic patients: A cohort study. Foot Ankle Int., 30: 1177-82, 2009.

20- LANDRY G.J., SILVERMAN D.A., LIEM T.K., et al.: Predictors of healing and functional outcome following transmetatarsal amputations. Arch. Surg., 146: 1005-9, 2011.

21- TERASHI H., KITANO I., TSUJI Y., et al.: A modified transmetatarsal amputation. J. Foot Ankle Surg., 50: 441-4, 2011.

22- BROWN M.L., TANG W., PATEL A., et al.: Partial foot amputation in patients with diabetic foot ulcers. Foot Ankle Int., 33: 707-16, 2012.

23- McCALLUM R. and TAGOE M.: Transmetatarsal amputation: A case series and review of the literature. J. Aging. Res., 797218, 2012.

24- DUBSKY´ M., JIRKOVSKÁ A., BEM R., et al.: Risk factors for recurrence of diabetic foot ulcers: Prospective follow-up analysis in the Eurodiale subgroup. Int. Wound J., 10 (5): 555-61, 2013.

25- O'BRIEN P.J., COX M.W., SHORTELL C.K., et al.: Risk factors for early failure of surgical amputations: An analysis of 8,878 isolated lower extremity amputation procedures. J. Am. Coll Surg., 216: 836-44, 2013.

26- QIAN H., XU L., ZHANG S., et al.: Disease course of patients with diabetic foot ulcer during one-year follow-up. J. Intern. Med. Cocepts. Pract., 8 (02): 124-7, 2013.

27- HU X., SHI L. and LIU S.: Analysis of risk factors for recurrence of foot ulcer in type 2 diabetes mellitus. Today Nurse, 22 (04): 23-4, 2014.

28- CHANG X., YUAN L., WANG F., et al.: Analysis of clinical outcomes and related factors in patients with diabetic foot after discharge. Chinese Nursing Research, 31 (36): 4634-7, 2017.

29- KHALIFA W.A.: Risk factors for diabetic foot ulcer recurrence: A prospective 2 year follow-up study in Egypt. Foot (Edinb), 35: 11-5, 2018.

30- MO Z., CHEN D., GAO Y., et al.: Risk factors for foot ulcer recurrence in diabetic patients with new-onset foot ulcers. China Tropical Nedicine, 18 (07): 716-9, 2018.

31- XIE C., CHEN Y., XIONG Y., et al.: Influencing factors of recurrences of the healed diabetic foot ulcers. Chin. J.Mult. Organ Dis. Elderly, 17 (07): 501-4, 2018.

32- HUANG Z., LI S., KOU Y., et al.: Risk factors for the recurrence of diabetic foot ulcers among diabetic patients: A meta analysis. International Wound Journal, 10: 111-32, 2019.

33- ARMSTRONG D.G., BOULTON A.J.M. and BUS S.A.: Diabetic foot ulcers and their recurrence. N. Engl. J. Med., 376 (24): 2367-75, 2017.

34- DIOURI A., SLAOUI Z., CHADLI A., et al.: Incidence of factors favoring recurrent foot ulcers in diabetic patients. Ann. Endocrinol. (Paris), 63 (6 Pt 1): 491-6, 2002.

35- WAAIJMAN R., De HAART M., ARTS M.L., et al.: Risk factors for plantar foot ulcer recurrence in neuropathic diabetic patients. Diabetes Care, 37 (6): 1697-705, 2014.

36- DARLING J.D., McCALLUM J.C., SODEN P.A., et al.: system following infrapopliteal endovascular interventions for critical limb ischemia. J. Vasc. Surg., 64 (3): 616-22, 2016.

37- CONNOR H. and MAHDI O.Z.: Repetitive ulceration in neuropathic patients. Diabetes Metab. Res. Rev., 20 (1): S23-S28, 2004.

38- NI P. and YUAN L.: Research Progress of influencing factors on recurrence of diabetic foot ulcer. J. Nurs. (China), 24 (09): 35-8, 2017.

39- HUNG S.Y., TSAI J.S., YEH J.T., et al.: Amino acids and wound healing in people with limb-threatening diabetic foot ulcers. Journal of Diabetes and its Complications, 33 (10): 107403, 2019.

40- MAI L., LI Y., ZHANG L., et al.: Five year recurrence rate of ulcer in patients with new-onset diabetic foot ulcer: Risk factors. J. Nurs. Sci., 31 (11): 18-21, 2016.

مخاطر حدوث قرح وإعادة البتر بعد عمل بتر جزئى للقدم فى مريض السكرى من النوع الثانى

قرح القدم السكرية هى واحدة من أخطر المضاعفات فى مرضى السكرى. يتراوح الخطر السنوى لتطوير قرح القدم فى مرضى السكرى من ١٩٪ إلى ٣٤٪. ما يقرب من ٤٠٪ من المرضى الذين يعانون من يعانون من تكرار قرح القدم السكريه فى غضون سنة واحدة بعد إلتئام القرحة.

تنجم تقرحات القدم المتكررة عن عوامل مختلفة له آثار سلبية على الحالة الفسيولوجية للمرضى، والصحة العقلية، والآداء الإجتماعى. كان الهدف من هذا التحليل هو السعى إلى تحديد مخاطر التقرح وإعادة البتر والوفاة فى مرضى السكرى بعد بتر الأطراف السفلية البسيطة، من خلال الأدبيات المتاحة، وتأثير أنشطة الحياة اليومية على النتائج السريرية.

فى هذا التحليل التلوى تم ذكر العمل كعامل خطر فى ثلاث أوراق من ثمانى أوراق بنسبة ٣٧.٥٪، حيث تم ذكر عامل الجنس فى ستة أوراق بنسبة ٧٥٪، حيث تم ذكر عامل التدخين فى خمس أوراق بنسبة ٦٢.٥٪، مثل مؤشر كتلة الجسم تم ذكر العامل فى ثلاث أوراق بنسبة ٣٧.٥٪، حيث تم ذكر عامل مدة الإصابة بمرض السكرى فى ثلاث أوراق بنسبة ٣٧.٥٪، حيث تم ذكر مدة عامل قرحة القدم السكرية السابقة فى ورقة واحدة بنسبة ١٢.٥٪ تم ذكر القرحة باطن القدم كعامل خطر. فى ثلاث أوراق واحدة بنسبة ١٢.٥٪. فى التحليل التلوى الذى أجريناه، تضمنت عوامل الخطر لتكرار حدوث تجلط الدم فى الجسم الذكور، والتدخين، والمدة الطويلة لمرض السكرى، والمدة الطويلة لقرح القدم السكريه السابقة، والقرحة الأخمصية، قصور الدوره الدموية الطرفية وقصور وظائف الكلى نتيجة مرض السكرى.